

CLAIMS:

1. A carrier comprising:

a magnetic core material; and

a layer located on a surface of the magnetic core material,

wherein the carrier satisfies the following relationships (1) to (3):

$$0.90 \leq (\sigma_a/\sigma_b) < 1.00 \quad (1)$$

$$200 \leq (\sigma_b \cdot \rho_c) \leq 400 \quad (2)$$

$$10 \leq (\sigma_b/\rho_c) \leq 20 \quad (3),$$

wherein σ_b represents a magnetization (emu/g) of the carrier at 1,000 Oe, ρ_c represents a true specific gravity of the carrier, and σ_a represents a magnetization of the carrier determined by the following method including:

(1) magnetically holding the carrier on a cylindrical sleeve having a magnetic pole area located over a magnetic pole and having a peak magnetic flux density of 100 mT in a direction perpendicular to an axis of the cylindrical sleeve;

(2) rotating the cylindrical sleeve around the axis thereof for about 30 min;

(3) removing the carrier from the magnetic pole area by applying a force which is three times as much as a weight of the carrier in the direction perpendicular to the axis of the cylindrical sleeve; and

(4) measuring a magnetization at 1,000 Oe to determine the magnetization σ_a ,

wherein the carrier has a weight-average particle diameter (D4) of about 25 to about 65 μm and includes carrier particles having a weight-average particle diameter not greater than about 12 μm in an amount not greater than about 0.3 % by weight,

wherein a ratio (D4/D1) between the weight-average particle diameter (D4) and a number-average particle diameter of the carrier (D1) is about 1 to about 1.3, and

wherein an electric resistance R is about 1.0×10^9 to about $1.0 \times 10^{11} \Omega \cdot \text{cm}$ when an AC voltage represented by the following formula (4) is applied at a frequency of 1,000 Hz to a magnetic brush of the carrier is formed between parallel plate electrodes having a gap of d mm such that magnetic brush has a space occupancy of about 40 %:

$$E(V) = 250 \times d \quad (4),$$

wherein d is 0.40 ± 0.05 mm and E is a peak voltage.

2. The carrier of Claim 1, wherein the carrier has an average surface vertical interval of about 0.1 to about 2.0 μm .

3. The carrier of Claim 1, wherein the layer comprises a resin and an insulative inorganic particulate material.

4. The carrier of Claim 1, wherein the magnetic core material includes a particulate ferrite.

5. The carrier of Claim 1, wherein the magnetic core material includes a particulate material in which a magnetic material is dispersed in a resin.

6. A two-component developer comprising:

a carrier comprising:

a magnetic core material; and

a layer located on a surface of the magnetic core material,

wherein the carrier satisfies the following relationships (1) to (3):

$$0.90 \leq (\sigma_a/\sigma_b) < 1.00 \quad (1)$$

$$200 \leq (\sigma_b \cdot \rho_c) \leq 400 \quad (2)$$

$$10 \leq (\sigma_b/\rho_c) \leq 20 \quad (3),$$

wherein σ_b represents a magnetization (emu/g) of the carrier at 1,000 Oe, ρ_c represents a true specific gravity of the carrier, and σ_a represents a magnetization of the carrier determined by the following method including:

(1) magnetically holding the carrier on a cylindrical sleeve having a magnetic pole area located over a magnetic pole and having a peak magnetic flux density of 100 mT in a direction perpendicular to an axis of the cylindrical sleeve;

(2) rotating the cylindrical sleeve around the axis thereof for about 30 min;

(3) removing the carrier from the magnetic pole area by applying a force which is three times as much as a weight of the carrier in the direction perpendicular to the axis of the cylindrical sleeve; and

(4) measuring a magnetization at 1,000 Oe to determine the magnetization σ_a ;

wherein the carrier has a weight-average particle diameter (D4) of about 25 to about 65 μm and includes carrier particles having a weight-average particle diameter not greater than about 12 μm in an amount not greater than about 0.3 % by weight,

wherein a ratio (D4/D1) between the weight-average particle diameter (D4) and a number-average particle diameter of the carrier (D1) is about 1 to about 1.3, and

wherein an electric resistance R is about 1.0×10^9 to about $1.0 \times 10^{11} \Omega \cdot \text{cm}$ when an AC voltage represented by the following formula (4) is applied at a frequency of 1,000 Hz to a magnetic brush of the carrier is formed between parallel plate electrodes having a gap of d mm such that magnetic brush has a space occupancy of about 40 %:

$$E (\text{V}) = 250 \times d \quad (4),$$

wherein d is 0.40 ± 0.05 mm and E is a peak voltage; and

a toner comprising:

a binder resin; and

a colorant.

7. The two-component developer of Claim 6, wherein the two-component developer comprises the toner in an amount of about 2 to about 12 % by weight.

8. The two-component developer of Claim 6, wherein the toner further comprises a release agent.

9. The two-component developer of Claim 6, wherein the toner has a weight-average particle diameter of about 4 to about 10 μm .

10. An image developer comprising:

a charger configured to frictionally charge a toner;

a rotatable holder including a magnetic field generator, which is configured to hold a two-component developer comprising:

a carrier comprising:

a magnetic core material; and

a layer located on a surface of the magnetic core material,

wherein the carrier satisfies the following relationships (1) to (3):

$$0.90 \leq (\sigma_a/\sigma_b) < 1.00 \quad (1)$$

$$200 \leq (\sigma_b \cdot \rho_c) \leq 400 \quad (2)$$

$$10 \leq (\sigma_b/\rho_c) \leq 20 \quad (3),$$

wherein σ_b represents a magnetization (emu/g) of the carrier at 1,000 Oe, ρ_c represents a true specific gravity of the carrier, and σ_a represents a magnetization of the carrier determined by the following method including:

(1) magnetically holding the carrier on a cylindrical sleeve having a magnetic pole area located over a magnetic pole and having a peak magnetic flux density of 100 mT in a direction perpendicular to an axis of the cylindrical sleeve;

(2) rotating the cylindrical sleeve around the axis thereof for about 30 min;

(3) removing the carrier from the magnetic pole area by applying a force which is three times as much as a weight of the carrier in the direction perpendicular to the axis of the cylindrical sleeve; and

(4) measuring a magnetization at 1,000 Oe to determine the magnetization σ_a ,

wherein the carrier has a weight-average particle diameter (D4) of about 25 to about 65 μm and includes carrier particles having a weight-average particle diameter not greater than about 12 μm in an amount not greater than about 0.3 % by weight,

wherein a ratio (D4/D1) between the weight-average particle diameter (D4) and a number-average particle diameter of the carrier (D1) is about 1 to about 1.3, and

wherein an electric resistance R is about 1.0×10^9 to about $1.0 \times 10^{11} \Omega \cdot \text{cm}$ when an AC voltage represented by the following formula (4) is applied at a frequency of 1,000 Hz to a magnetic brush of the carrier is formed between parallel plate electrodes having a gap of d mm such that magnetic brush has a space occupancy of about 40 %:

$$E (\text{V}) = 250 \times d \quad (4),$$

wherein d is 0.40 ± 0.05 mm and E is a peak voltage; and

a toner comprising:

a binder resin; and

a colorant; and

an image bearer configured to bear an electrostatic latent image thereon, wherein the electrostatic latent image is developed with the two-component developer at a developing area located between the image bearer and the rotatable holder,

wherein a maximum magnetic flux density B (mT) at the developing area in a normal direction of a surface of the rotatable holder satisfies the following relationship (5):

$$(15,000/(\sigma_a \cdot \rho_c)) \leq B \leq (50,000/(\sigma_b \cdot \rho_c)) \quad (5).$$

11. The image developer of Claim 10, wherein a minimum distance between the rotatable holder and the image bearer is about 0.30 to about 0.80 mm.

12. The image developer of Claim 10, further comprising a voltage applicator configured to apply a DC bias voltage to the rotatable holder.

13. The image developer of Claim 12, wherein the voltage applicator applies a DC bias voltage overlapped with an AC voltage to the rotatable holder.

14. The image developer of Claim 10, further comprising a recycler comprising:
a cleaner configured to clean the image bearer by collecting the toner remaining on a surface of the image bearer; and
a returner configured to return the collected toner to the rotatable holder.

15. An image forming apparatus comprising:
a plurality of image developers configured to develop an electrostatic latent image with a developer to form a toner image;

a transferer configured to transfer the toner image onto a transfer medium; and

a fixer configured to fix the toner image on the transfer medium,

wherein the plurality of image developers includes an image developer comprising:

a charger configured to frictionally charge a toner;

a rotatable holder including a magnetic field generator, which is configured to hold a two-component developer comprising:

a carrier comprising:

a magnetic core material; and

a layer located on a surface of the magnetic core material,

wherein the carrier satisfies the following relationships (1) to (3):

$$0.90 \leq (\sigma_a / \sigma_b) < 1.00 \quad (1)$$

$$200 \leq (\sigma_b \cdot \rho_c) \leq 400 \quad (2)$$

$$10 \leq (\sigma_b / \rho_c) \leq 20 \quad (3),$$

wherein σ_b represents a magnetization (emu/g) of the carrier at 1,000 Oe, ρ_c represents a true specific gravity of the carrier, and σ_a represents a magnetization of the carrier determined by the following method including:

(1) magnetically holding the carrier on a cylindrical sleeve having a magnetic pole area located over a magnetic pole and having a peak magnetic flux density of 100 mT in a direction perpendicular to an axis of the cylindrical sleeve;

(2) rotating the cylindrical sleeve around the axis thereof for about 30 min;

(3) removing the carrier from the magnetic pole area by applying a force which is three times as much as a weight of the carrier in the direction perpendicular to the axis of the cylindrical sleeve; and

(4) measuring a magnetization at 1,000 Oe to determine the magnetization σa ,

wherein the carrier has a weight-average particle diameter (D4) of about 25 to about 65 μm and includes carrier particles having a weight-average particle diameter not greater than about 12 μm in an amount not greater than about 0.3 % by weight,

wherein a ratio (D4/D1) between the weight-average particle diameter (D4) and a number-average particle diameter of the carrier (D1) is about 1 to about 1.3, and

wherein an electric resistance R is about 1.0×10^9 to about 1.0×10^{11} $\Omega \cdot \text{cm}$ when an AC voltage represented by the following formula (4) is applied at a frequency of 1,000 Hz to a magnetic brush of the carrier is formed between parallel plate electrodes having a gap of d mm such that magnetic brush has a space occupancy of about 40 %:

$$E (\text{V}) = 250 \times d \quad (4),$$

wherein d is 0.40 ± 0.05 mm and E is a peak voltage; and

a toner comprising:

a binder resin; and

a colorant; and

an image bearer configured to bear an electrostatic latent image thereon, wherein the electrostatic latent image is developed with the two-component developer at a developing area located between the image bearer and the rotatable holder,

wherein a maximum magnetic flux density B (mT) at the developing area in a normal direction of a surface of the rotatable holder satisfies the following relationship (5):

$$(15,000/(\sigma a \cdot \rho c)) \leq B \leq (50,000/(\sigma b \cdot \rho c)) \quad (5).$$

16. A process cartridge comprising a member selected from the group comprising photoreceptors, chargers, image developers, and cleaners, wherein the image developers include an image developer comprising:

a charger configured to frictionally charge a toner;

a rotatable holder including a magnetic field generator, which is configured to hold a two-component developer comprising:

a carrier comprising:

a magnetic core material; and

a layer located on a surface of the magnetic core material,

wherein the carrier satisfies the following relationships (1) to (3):

$$0.90 \leq (\sigma_a / \sigma_b) < 1.00 \quad (1)$$

$$200 \leq (\sigma_b \cdot \rho_c) \leq 400 \quad (2)$$

$$10 \leq (\sigma_b / \rho_c) \leq 20 \quad (3),$$

wherein σ_b represents a magnetization (emu/g) of the carrier at 1,000 Oe, ρ_c represents a true specific gravity of the carrier, and σ_a represents a magnetization of the carrier determined by the following method including:

(1) magnetically holding the carrier on a cylindrical sleeve having a magnetic pole area located over a magnetic pole and having a peak magnetic flux density of 100 mT in a direction perpendicular to an axis of the cylindrical sleeve;

(2) rotating the cylindrical sleeve around the axis thereof for about 30 min;

(3) removing the carrier from the magnetic pole area by applying a force which is three times as much as a weight of the carrier in the direction perpendicular to the axis of the cylindrical sleeve; and

(4) measuring a magnetization at 1,000 Oe to determine the magnetization σ_a ,

wherein the carrier has a weight-average particle diameter (D4) of about 25 to about 65 μm and includes carrier particles having a weight-average particle diameter not greater than about 12 μm in an amount not greater than about 0.3 % by weight,

wherein a ratio (D4/D1) between the weight-average particle diameter (D4) and a number-average particle diameter of the carrier (D1) is about 1 to about 1.3, and

wherein an electric resistance R is about 1.0×10^9 to about 1.0×10^{11} $\Omega \cdot \text{cm}$ when an AC voltage represented by the following formula (4) is applied at a frequency of 1,000 Hz to a magnetic brush of the carrier is formed between parallel plate electrodes having a gap of d mm such that magnetic brush has a space occupancy of about 40 %:

$$E (\text{V}) = 250 \times d \quad (4),$$

wherein d is 0.40 ± 0.05 mm and E is a peak voltage; and

a toner comprising:

a binder resin; and

a colorant; and

an image bearer configured to bear an electrostatic latent image thereon, wherein the electrostatic latent image is developed with the two-component developer at a developing area located between the image bearer and the rotatable holder,

wherein a maximum magnetic flux density B (mT) at the developing area in a normal direction of a surface of the rotatable holder satisfies the following relationship (5):

$$(15,000/(\sigma_a \cdot \rho_c)) \leq B \leq (50,000/(\sigma_b \cdot \rho_c)) \quad (5).$$

17. A carrier comprising:

a magnetic core material; and

a layer located on a surface of the magnetic core material,

wherein the carrier satisfies the following relationships (1) to (3):

$$0.90 \leq (\sigma_a / \sigma_b) < 1.00 \quad (1)$$

$$200 \leq (\sigma_b \cdot \rho_c) \leq 400 \quad (2)$$

$$10 \leq (\sigma_b / \rho_c) \leq 20 \quad (3),$$

wherein σ_b represents a magnetization (emu/g) of the carrier at 1,000 Oe, ρ_c represents a true specific gravity of the carrier, and σ_a represents a magnetization of the carrier determined by the following apparatus including:

(1) means for magnetically holding the carrier on a cylindrical sleeve having a magnetic pole area located over a magnetic pole and having a peak magnetic flux density of 100 mT in a direction perpendicular to an axis of the cylindrical sleeve;

(2) means for rotating the cylindrical sleeve around the axis thereof for about 30 min;

(3) means for removing the carrier from the magnetic pole area by applying a force which is three times as much as a weight of the carrier in the direction perpendicular to the axis of the cylindrical sleeve; and

(4) means for measuring a magnetization at 1,000 Oe to determine the magnetization σ_a ,

wherein the carrier has a weight-average particle diameter (D4) of about 25 to about 65 μm and includes carrier particles having a weight-average particle diameter not greater than about 12 μm in an amount not greater than about 0.3 % by weight,

wherein a ratio (D4/D1) between the weight-average particle diameter (D4) and a number-average particle diameter of the carrier (D1) is about 1 to about 1.3, and

wherein an electric resistance R is about 1.0×10^9 to about $1.0 \times 10^{11} \Omega \cdot \text{cm}$ when an AC voltage represented by the following formula (4) is applied at a frequency of 1,000 Hz to a magnetic brush of the carrier is formed between parallel plate electrodes having a gap of d mm such that magnetic brush has a space occupancy of about 40 %:

$$E (\text{V}) = 250 \times d \quad (4),$$

wherein d is 0.40 ± 0.05 mm and E is a peak voltage.

18. The carrier of Claim 17, wherein the carrier has an average surface vertical interval of about 0.1 to about 2.0 μm .

19. The carrier of Claim 17, wherein the layer comprises a resin and an insulative inorganic particulate material.

20. The carrier of Claim 17, wherein the magnetic core material includes a particulate ferrite.

21. The carrier of Claim 17, wherein the magnetic core material includes a particulate material in which a magnetic material is dispersed in a resin.